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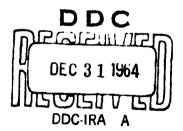
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THE MICROBIOLOGICAL DETERIORATION OF HYDROCARBONS AND THE RELATED DEGRADATION OF EQUIPMENT USED FOR THE STORAGE, DISTRIBUTION AND HANDLING OF PETROLEUM PRODUCTS

Supplement No. 1

by

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FOREWORD

This Bibliography is a supplement to the Microbiological Series Report No. 5, The Microbiological Deterioration of Hydrocarbons and the Related Degradation of Equipment Used for the Storage, Distribution and Handling of Petroleum Products, Chemicals and Plastics Division, June 1961. These references have been compiled for use in the Quartermaster research program on the microbiological deterioration of fuels, fuel storage tanks, and pipelines. They are listed with the thought that they may be useful to others conducting research in these areas.

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I Microbiological Deterioration of Hydrocarbons and Related Organic Compounds

- 1. Appert, J. and Louis, M., "Attack on Crude Oil by Microorganisms", (In French), Rev. inst. franc. petrole et Ann. combustibles liquides, 10:345-348, May, 1955.
- 2. Booser, E.R. and Fenske, M.R., "Liquid Phase Hydrocarbon Oxidation", Ind. Eng. Chem., 14:1850-1856, Aug., 1952.
- 3. Davis, J.B. and Raymond, R.L., "Oxidation of Alkyl-substituted Cyclic Hydrocarbons by a Nocardia during Growth on n-alkanes", Applied Microbiol., 9(5):383-388, Sept., 1961.
- 4. Fuhs, G. Wolfgang, "The Microbial Degradation of Hydrocarbons", (In German), Arch. Mikrobiol., 39:374-422, 1961.
- 5. Gängel, G. and Schwartz, W., "Investigations in Petroleum Bacteriology.
 III. Occurrence of Microorganisms in Petroleum Products", (In German),
 Z. Hyg. Infectianskrankheiten, 140(1):100-126, 1954.
- 6. Ginzburg Karagicheva, T.L., "Microbiology of Petroleum", (In Russian), Priroda, 41(3):26-31, 1958.
- 7. Heringa, J.W., Huybregtse, Rosalina and Van Der Linden, A.C., "n-Alkane Oxidation by a <u>Pseudomonas</u>. Formation and B-Oxidation of Intermediate Fatty Acids", Antonie van Leeuwenhoek, 27(1):51-58, 1961.
- 8. Kolesnik, Z.A. and Shmonova, N.I., "On the Study of Oil Variation in Anaerobic Conditions under the Influence of Bacteria of the Pseudomonas Genus", (In Russian), Doklady Akad. Nauk S.S.S.R., 115:1197-1199, 1957.
- 9. National Research Council, Prevention of Deterioration Center, "Bibliography on Microorganisms Affecting Petroleum and Petroleum Products, Including Reports on Sulfate-Reducing Bacteria", 17p., Aug., 1961.
- 10. Nickerson, Walter J., "Transformation of Carbon Compounds by Microorganisms", Ind. Eng. Chem., 48(9):1411-1420, Sept., 1956.
- 11. Perlman, D., "Transformations of Organic Compounds by Microorganisms", J. Chem. Educ., 36(2):60-63, Feb., 1959.

- 12. Raymond, R.L. and Davis, J.B., "n-Alkane Utilisation and Lipid Formation by a Nocardia", Appl. Microbiol., 8(6):329-334, Nov., 1960.
- 13. Solari, A.A., Herrero, Mario and deCremaschi, Maria S.D., "Biochemical Properties of Pseudomonas aeruginosa I. Action on Hydrocarbons", (In Spanish), Rev. Fac. Cienc. Quim., Univ. Nacl. La Plata 31 (1958):45-48, 1959.

II Microbiological Problems Involving Storage and Use of Fuels

- lu. Allen, F.H., "The Biological Deverioration of Thiokol Limings for Gasoline Storage Tanks", NRL Report P-2902, July, 1946.
- 15. Chertkov, Ya. B., et al, "Corrosive Activity of Hydrocarbon Fuels in Presence of Elementary Sulfur", (In Russian), Khimiya: Tekhnologiya Topliv i Masel 7:62-66, July, 1958.
- 16. Donahue, Terance B., "Microbiological Fuel Contamination and Corrosion", Lockheed Field Service Digest, 7(5):3-13, March-April, 1961.
- 17. Gwinn, S.H., et al, "Gas Turbine and Jet Engine Fuels", Phillips Petroleum Company, Research Division Report 2005-58R, 2066-58R, 2208-58R, 2262-58R, 2328-59R, 1958-1959.
- 18. Hazzard, G.F., "Fungal Growths in Aviation Fuel Systems", Part 1, Dept. of Supply, Aust. Defense Scientific Service, Defense Standard Laboratory Report 252, Aug., 1961.
- 19. James, Robert R. and Morris, Ross E., "Suitability of Gasolines as Fuels", Ind. Eng. Chem., 40:405-411, March, 1948.
- 20. Johnson, C.R., Fink, D.F. and Nixon, A.C., "Stability of Aircraft Turbine Fuels", Ind. Eng. Chem., μ6:2166-2173, Oct., 1954.
- 21. Kelly, C.D. and Pady, S.M., "Microbiological Studies of Air over some Non-Arctic Regions of Canada", Can. J. Botany, 31:90-106, Jan., 1953.
- 22. Kramer, C.L., Pady, S.M., and Rogerson, C.T., "Kansas Aeromycology. 3. Cladosporium", Kansas Acad. Sci., Trans., 62:200-207, 1959.
- 23. Lockheed Airplane Company, "Fuel Tank Corrosion", Lockheed Service News, No. 29, July-Aug., 1961.
- 24. Machine Design Magazine, "Jet Fuel? Delicious, say Fungi", Machine Design, 32(7):12, March 31, 1960.
- 25. N.A.M.L. Report, "Contamination of H.M.S. Victorious' Aveat with Water and Fungal Organisms", Naval Aircraft Materials Laboratory Report F/ECH, Royal Naval Aircraft Yard, Fleetlands, Great Britain, 1959. (Limited Distribution).
- 26. N.A.M.L. Report, "Fungal Contamination of the Avcat Fuel Systems of H.M. Aircraft Carriers, Victorious, Eagle, Albion and Centaur", Naval Aircraft Materials Laboratory Report F/ECH/2, Royal Naval Aircraft Yard, Fleetlands, Great Britain, (Limited Distribution).

- 27. N.A.M.L. Report, "Fungal Contamination of Avcat Fuel Systems, Laboratory Examination of Fungicidal Preparations", Naval Aircraft Materials Laboratory Report F/ECH/3, Royal Naval Aircraft Yard, Fleetlands, Oreat Britain, (Limited Distribution).
- 28. Pady, S.M. and Kapica, Lucia, "Air-borne Fungi in the Arctic and other Parts of Canada", Can. J. Botany, 31:309-323, May, 1953.
- 29. Pady, S.M. and Kelly, C.D., "Studies on Microorganisms in Arctic Air During 1949 and 1950", Can. J. Botany, 31:107-122, Jan., 1953.
- 30. Pady, S.M. and Kelly, C.D., "Numbers of Fungi and Bacteria in Transatlantic Air", Science, 117:607-609, May, 1953.
- 31. Schläpfer, P. and Bukowiecki, A., "Study of Corrosive Attack by Motor Fuels", (In German), Schweiz. Arch. angew. Wiss. u. Tech., 14:257-274, Sept., 1948.
- 32. Sergienko, S.R. and Galich, P.N., "Causes of the Gumming of Diesel Fuels During Storage", (In Russian), Zhur. Priklad. Khim., 30:1653-1660, 1957.
- 33. Shell Oil Company, "Jet Fuel Contaminants and Their Significance", Products Application Department, Report No. 166, Sept., 1961.
- 34. Sneed, R.W., Ballentine, O.M., and Winterhaulter, J.H., "Accelerated Storage Stability of Aviation Fuels", WADC Tech. Report 55-138, 30p., March, 1957.
- 35. Stormont, D.H., "Do Jet Fuel Bacteria Cause Slime, Corrosion", Oil Gas J., 59(27):82-84, July 3, 1961.
- 36. Symposium on Contamiration of Jet Fuel. Held 13-14, Sept., 1961, at The Pentagon, Washington, D.C. (Limited Distribution).
- 37. Thompson, Ralph B., Druge, L.W. and Chenicek, J.A., "Stability of Fuel Oils in Storage. Effect of Sulfur Compounds", Ind. Eng. Chem., 41:2715-2721, Dec., 1949.
- 38. Walters, E.L. and Busso, C.J., "Oxidation Stability of Tetraethyllead and Leaded Aviation Gasolines", Ind. Eng. Chem., 41:907-914, May, 1949.
- 39. Ward, C.C., et al, "Distillate Fuel Storage Stability. Studies Relating to Causes of Instability", Western Petroleum Refiners Assoc., Tulsa, Okla., Summary Report 2, 109 pages, Oct., 1958.

III Microbiological Deterioration and Related Corrosion Problems in Industry

A. The Petroleum Industry

- 40. Boas, N., "Corrosion in Petroleum Distribution Plant", Symposium on Corrosion, Univ. of Melbourne, pp 511-524, 1956.
- 41. Grad, N. M. and Sudakov, Yu. T., "Determination of the Real Corrosion by Oils", (In Russian), Zhur. Priklad. Khim., 33:1586-1590, July, 1960.
- 12. Hadley, R.F., "Methods of Studying Microbiological Anaerobic Corrosion of Pipelines", Petroleum Engineer, pp 171-176, March, 1940.
- 43. Harris, John O., "Pipeline Protective Coating Materials as Growth Substrates for Soil Microorganisms", Trans. Kansas Acad. Sci., 62:42-46, 1959.
- 44. Harris, John O., "The Pipeline Back-Filled Ditch as an Environment for Soil Microorganisms", Proc. 4th Annual Appalachian Underground Corrosion Short Course, West Virginia Univ., 1959.
- 45. Harris, John O., "Microbiological Studies Reveal Significant Factors in Oil and Gas Pipeline Back-Filled Ditches", Tech. Bull. 102, Kansas State University, Kansas Agricultural Experiment Station, Manhattan, Kansas, May 20, 1959.
- 46. Harris, John O., "Soil Microorganisms in Relation to Cathodically Protected Pipe", Corrosion, 16:113-120, Sept., 1960.
- 47. Harris, John O., "Soil Bacteria and Corrosion", Proc. 6th Annual Appalachian Underground Corrosion Short Course, West Virginia University, 1961.
- 48. Harris, John O., "Bacteria and Pipeline Corrosion", Proc. American Gas Assoc. Combined Distribution Production Conf., May 8-12, 1961, Philadelphia, Penna.
- 49. Harris, John O., "Soil Bacteria and Pipeline Corrosion", Proc. American Gas Assoc., Operating Section Distribution Conf., 1961.
- 50. Kulman, Frank E., "Microbiological Deterioration of Buried Pipe and Cable Coatings", Corrosion, 14:213T-222T, May, 1958.
- 51. Kulman, Frank E., "Microbiological Corrosion of Buried Steel Pipe", Corrosion, 9:11-18, Jan., 1953.

- 52. Lada, Arnold, "The Role of Microorganisms in Secondary Oil Recovery", Proc. 45th Ann. Chem. Spec. Mfgrs. Assoc., pp 123-125, Dec. 8-10, 1958.
- 53. Lada, Arnold, "Microorganisms are Bad Actors in Water Flooding", 011 Gas J., 57(16):93, 1959.
- 54. LaRivière, J.W.M., "The Production of Surface Active Compounds by Microorganisms and its Possible Significance in Oil Recovery. 1. Some General Observations on the Change of Surface Tension in Microbial Cultures", Antonie van Leeuwenhoek, J. Mikrobiol. Serol., 21:1-8, 1955.
- 55. Minchin, Leslie T., "Bacterial Corrosion of Underground Pipes", Coke and Gas (England), 22:392-397, 411, Sept., 1960.
- 56. Phelps, E.H., "How Research on Steel Corrosion is Reducing Cost in the Petroleum Industry", Oil Gas J., 59(2):79-80, Jan. 9, 1961.
- 57. Powell, H.M., "Corrosion in the Oil Industry", Corrosion Prevention and Control, 6(10):46-48, Oct., 1959.
- 58. Putilova, I.N. et al, "Corrosion of Steel by Kerosene and Methods of Prevention", (In Russian), Zhur. Priklad. Khim., 26:148-154, Feb., 1953.
- 59. Putilova, I.N., Gindin, L.G. and Artamonova, E.V., "Corrosion of Metals by Saturated Fuel" (In Russian), Doklady Akad. Nauk S.S.S.R., 94:489-492, Jan., 1954.
- 60. Raifsnider, P.J. and Wachter, A., "Pitting Corrosion by Water Flood Brines", Corrosion, 17:325T-328T, July, 1961.
- 61. Tandy, Edward H., "Corrosion in Light Oil Storage Tanks", Corrosion, 13:23-28, July, 1957.
- 62. Wieland, R. and Treseder, R.S., "Internal Corrosion in Domestic Fuel Oil Tanks", Corrosion, 10:401-406, Nov., 1954.
- 63. Yeager, Charles C., "Microbial Problems in the Refining of Oil", Proc. 45th Ann. Chem. Spec. Mfgrs. Assoc., pp. 120-123, Dec. 8-10, 1958.

B. Other Industries

- 64. Al'bitskaya, O.N. and Shaposhnikova, N.A., "The Effect of Molds on the Corrosion of Metals", (In Russian), Mikrobiologiya, 29:725-730, Sept.-Oct., 1960.
- 65. Baudon, Lucien, "The Part Played by Microorganisms in Certain Corrosion Phenomena", (In French), Industrie chimique belge, 23:983-990, Sept., 1958.
- 66. Ben'kovskii, V.G., Bogoslavakaya, T.M. and Drizo, E.A., "Some Causes of Deterioration of Anticorrosive Bituminous Coatings", (In Russian), Akademiia nauk Kazakhskoi SSR, Alma-Alta., Institut nefti. Trudy 1:65-75, 1956.
- 67. Blake, J.T., Kitchin, D.W. and Pratt, O.S., "Failures of Rubber Insulation Caused by Soil Microorganisms", AIEE Trans. 69, Part II, pp. 748-754, 1950.
- 68. Blake, J.T., Kitchin, D.W. and Pratt, O.S., "The Microbiological Deterioration of Rubber Insulation", AIEE Trans. 72, Part III, pp. 321-328, 1953.
- 69. Butlin, K.R. and Vernon, W.H.J., "The Underground Corrosion of Ferrous Metals in the Light of Recent Research", Proc. Chem. Eng. Group, (Soc.Chem.Ind.), 31:65, 1949.
- 70. Copenhagen, W.J., "Corrosion of Steel and Alclad Parts by a Fungus", Metal Industry, 77:137, 1950.
- 71. Gel'd, P.V. and Krasnovskaya, A.K., "Mechanism of the Sulphide Corrosion of Iron", (In Russian), Jour. Phys. Chem., 34(7), July, 1960.
- 72. Hache, A., Barriety, L. and Debyser, J., "Influence of Photosynthesis on the Corrosion of Steel in Salt Water", (In French), Corrosion et Anti-corrosion, 7:56-61, Feb., 1959.
- 73. Kalinenko, V.O., "Bacterial Colonies on Metal Plates in Sea Water", (In Russian), Mikrobiologiya, 28:750-756, Sept.-Oct., 1959.
- 74. Lockheed Aircraft Corp., "Corrosion", Lockheed Field Service Digest, 1(6):1-19, May-June, 1955.
- 75. National Research Council, Prevention of Deterioration Center, Scientific Advisory Committee, "Metal Metabolism and Microbiological Deterioration", NRC Publication 514, 31 p., June, 1956.

- 76. Nikitina, N.S. and Ulanovskii, I.B., "Some Data on the Microbiological Factors of the Corrosion of Steel in Sea Water", (In Russian), Akad Nauk S.S.S.R., Trudy. No. 3:190-200, 1957.
- 77. Olsen, Erik, "Aerobic Microbiological Corrosion of Water Pipes", Corrosion, 6:405-414, 1950.
- 78. Ranucci-Gatto, L., "Preliminary Research on the Possible Influence of Bacterial Metabolism on the Corrosion of Aluminum by Stagnant Water", (In Italian), Alluminio, 23:399-411, July, 1954.
- 79. Rowe, Leonard C. and Walker, Monte S., "Effect of Mineral Impurities in Water on the Corrosion of Aluminum and Steel", Corrosion 17:353T-356T, July 1, 1961.
- 80. Seelmeyer, Günther, "The Biological Corrosion of Iron", (In German), Werkstoffe u. Korrosion, 4:241-247, July, 1953.
- 81. Sharpley, J.M., "The Occurrence of Gallionellain Salt Water", Applied Microbiol., 9(5):380-382, Sept., 1961.
- 82. Ulanovskii, I.B. and Nikitina, N.S., "The Influence of Putrifying Aerobic Bacteria on the Corrosion of Steel in Sea Water", (In Russian), Mikrobiologiya, 25:66-71, Jan.-Feb., 1956.
- 83. Ulanovskii, I.B., Rozenberg, L.A. and Korovin, Yu. M., "The Effect of Bacteria upon the Electrode Potentials of Stainless Steels in Sea Water", (In Russian), Mikrobiologiya, 29:281-286, 1960.
- 84. Wise, R.S., "Significance of Slime in Causing Corrosion and Mechanisms of Corrosion by Slime Growth", Amer. Soc. Mech. Eng., New York, Paper 55-S40, pp. 9, 1955.

IV The Relationship Between Sulphate-Reducing Bacteria and Corrosion

- 85. Booth, G.H. and Tiller, A.K., "Polarization Studies of Mild Steel in Cultures of Sulphate-Reducing Bacteria", Trans. Faraday Soc., 56:1689-1696, Nov., 1960.
- 86. Campbell, L. Leon, Jr., Frank, Hilmer A. and Hall, Elizabeth R.,
 "Studies on Thermophilic Sulfate Reducing Bacteria. 1. Identification of Sporovibrio desulfuricans as Clostridium nigrificans",
 J. Bacteriol. 73:516-521, April, 1957.
- 87. Horvath, J., "Contributions to the Mechanism of Anaerobic Microbiological Corrosion", Acta Chim. Hung. Tomus, 25:65-78, 1960.
- 88. Horvath, J. and Solti, M., "The Mechanism of Anaerobic Microbiological Corrosion of Metals in Soil", (In German), Werkstoffe u. Korrosion 10:624-630, Oct., 1959.
- 89. Mackenzie, K., "The Metabolism of Vibrio desulpuricans in Anaerobic Petroliferous Formations", Biochem. J., 51:xxiv-xxv, 1952.
- 90. McVey, Roger E., "Soil Oxidation-Reduction Potential and its Determination as Related to Anaerobic Corrosion of Buried Steel", Proc. Appalachian Underground Corrosion Short Course, West Virginia Univ., 1959.
- 91. Miller, L.P., "Formation of Metal Sulfides Through the Activities of Sulfate-Reducing Bacteria", Contrib. Boyce Thompson Inst., 16(3): 85-89, 1950.
- 92. Senez, Jacques C., "Investigations on Biological Corrosion in Anaerobic Soils by Sulfate-Reducing Bacteria", (In French), Corrosion et Anti-Corrosion 1:131-132, Nov.-Dec., 1953.
- 93. Solti, M. and Horvath, J., "The Influence of Anaerobic Bacteria on the Current Density of Cathodically Protected Equipment in Soils", (In German), Werkstoffe u. Korrosion, 9:283-291., May, 1958.
- 94. Updegraff, D.M. and Wren, Gloria B., "The Release of Oil from Petroleum-Bearing Materials by Sulfate-Reducing Bacteria", Applied Microbiol. 2:309-322, Nov., 1954.
- 95. Wanklyn, J.N. and Spruit, C.J.P., "Influences of Sulfate-Reducing Bacteria on the Corrosion Potential of Iron", Nature, 169:928-929, 1952.

V Progress in the Inhibition of Microbially Induced Deterioration and Corrosion

- 96. A.P.I. Bulletin, "Turbine Aircraft Fuel Quality Protection at Airports", Supplement A to API Publication 1503, 3rd Edition, 8p., 1959.
- 97. A.P.I. Bulletin, "The Filtration and Dehydration of Aviation Fuels",
 API Publication 1501, 12p., American Petroleum Inst., N.Y., N.Y., 1960.
- 98. Aronov, D.I., et al, "Effect on Engine Wear of Anti-Knock Additives to Gasoline", (In Russian), Chem. and Tekn.of Fuels and Oils, Vol. 7, July, 1960.
- 99. Barusch, M.R., Piehl, R.L., and Haskell, L.G., "Control of Internal Corrosion of Products Pipe Lines with Oil-Soluble Inhibitor", Corrosion, 15:158T-166T, March, 1959.
- 100. Bennett, E.O., "Factors Involved in the Preservation of Metal Cutting Fluids", Developments in Industrial Microbiology, Vol. 3, 1962. In Press.
- 101. Bennett, E.O. and Futch, H.N., "Nitroparaffin Inhibitors for Cutting Fluids", Lubrication Eng. 16:228-230, May, 1960.
- 102. Cavallero, Leo, "The Use of Corrosion Inhibitors in the Petroleum Industry", (In French), Corrosion et Anticorrosion, 7:417-433, Dec., 1959.
- 103. Churchill, Arthur V. and Leathen, William W., "Development of Microbiological Sludge Inhibitors", Gulf Research & Development Company, ASD Technical Report 61-193, June, 1961.
- 104. Damonte, W.N., Watkins, F.M. and Wilkinson, T.T., "Corrosion Control By a Product Soluble Inhibitor in Clean Oil Tankers", API Central Committee on Transportation by Water, White Sulphur Springs, W. Va., June 9, 1958.
- 105. Darling, Samuel M., Fay, Philip S. and Szabo, Iorraine S., "Leaded Motor Fuel Containing Boron Compounds", U.S. Patent 2,741,548, April 10, 1956.
- 106. Dress, Vern, "Protecting Integral Fuel Tanks from Corrosion", Lockheed Field Service Digest, 3(6):19-23, May-June, 1957.
- 107. Fiedler, E.W., "A Case History of Repairs to Large Steel Storage Tanks with Polyester, Epoxy Resins", Navy Civil Eng., 2:11-13, 24, May, 1961.

- 108. Flemming, C.D. and Baker, R.J., "Controlling the Spoilage of Water Soluble Cutting Fluids", Lub. Eng., 16(9):444, 1960.
- 109. Fritts, C.J. (Chairman), "Protective Coatings in Petroleum Production", Corrosion, 17:251T-266T, May, 1961.
- 110. Griffith, J.R., "Fungicides for Concrete Fuel Tank Linings (type 53)", NRL Memorandum Report 1151, March, 1961.
- 111. Hanna, A.E., "Cathodic Protection Studies", Technical Report 145, U.S. Naval Civil Engineering Laboratory, July 21, 1961.
- 112. Hess, William A., "Refinery Corrosion Rates Below 5 mpy Achieved by Chromate Water Treatment", Corrosion, 16:18, 20-21, July, 1960.
- 113. Hitzman, Donald O. and Schneider, Ralph F., "Microbiological Corrosion Protection by Germicidal Zone and Protective Coating", U.S. Patent 2,979,377, April 11, 1961.
- 114. Hodge, Edward B., "Petroleum Lubricants Stabilized Against Hydrocarbon Metabolizable Microorganisms", U.S. Patent 2,913,414, Nov. 17, 1959.
- 115. Jaegers, Kurt, "Stabilized Cutting Oil Emulsions", German Patent 941091, April 5, 1956.
- 116. Johnson, W.A., "Save Tanks with Cathodic Protection", Petroleum Refiner 35(3):216-217, March, 1956.
- 117. Kasten, Walter, "Report on the Bendix "Go-No-Go" Gage for Jet Fuel Cleanliness", Presented to the Aviation Technical Service Committee, American Petroleum Institute, Montreal, Canada, April 18, 1961.
- 118. Kasten, Walter, "Go-No-Go Gage for Foolproof Fuel Cleanliness Check", Space/Aeronautics, May, 1961.
- 119. Keane, John D. and Bigos, Joseph, "Test of Paints for Water Tank Interiors", J. Am. Water Works Assoc. 52:623-630, May, 1960.
- 120. Krotov, I.V. and Khachadurova, T.M., "Corrosion of Iron in Contact with Gasoline or Kerosene and with an Aqueous Solution of an Electrolyte Containing Potassium Chromate Additives", (In Russian), Zhur. Priklad. Khim., 26:605-611, June, 1953.
- 121. Krotov, I.V. and Klubova, V.V., "Corrosion of Iron in Contact with an Aqueous Electrolyte Solution Containing an Addition of Sodium Nitrite and with a Liquid Fuel", (In Russian), Zhur. Priklad. Khim., 27:201-206, Oct., 1954.

- 122. Leonard, John M. and Weaver, Warren E., "Fungus Inhibitive Properties of Organic Compounds.Part I. Hydrocarbons and their Halides", NRL Report No. C-3289, May, 1948.
- 123. Lowry, Charles D., "Oxidation Inhibitors for Gasoline", Oil Gas J., 46(48):211-215, April, 1948.
- 12h. Ludzack, F.J. and Ettinger, M.B., "Chemical Structures Resistant to Aerobic Biochemical Stabilization", Pres. at 1hth Ind. Waste Conf., Purdue Univ., Lafayette, Ind. May 5-7, 1959.
- 125. Munger, C.G., "Picking a Coating to Resist Water Corrosion", Materials in Design Eng., 53:71-75, Jan., 1961.
- 126. Oosterhout, J.C.D., Stanley, M.E. and Quimby, W.S., "Corrosion Prevention in Tankers and Storage Tanks by Fogging and Flotation with an Inhibitor Solution", Corresion, 15:241T-244T, May, 1959.
- 127. Parker, W.D. and Wilkie, A.G., "Anti-corrosion Coatings for Buried Pipes", Industry Fights Corrosion: Proceedings of the Corrosion Convention, p. 98-105, Oct., 1957.
- 128. Pedersen, C.J., "Inhibition of Deterioration of Cracked Gasoline During Storage", Ind. Eng. Chem., 41:924-928, May, 1949.
- 129. Pourbaix, M., "Cenditions for the Cathodic Protection of Metals", (In German), Werkstoffe u. Korrosion, 11:761-766, Dec., 1960.
- 130. Quimby, W.S., "Oil-Soluble Inhibitors for Controlling Corrosion in Tankers and Pipe Lines", Corrosion, 16:9,10,12,14,16,18, March, 1960.
- 131. Radut, W.H. and Koehler, J.F., "Methods to Control Corrosion in Clean Oil Tankers", API Central Committee on Transportation by Water, Absecon, N.J., June 13, 1956.
- 132. Robinson, J.G. and Fleming, K., "Corresion of Tanker Hulls and its Prevention", Paper before Inst. Petrol. and Soc. Chem. Industry, Joint Symposium, London, Nov., 26-27, 1959.
- 133. Robinson, R.M., "Protective Coatings for Corrosion Control in Production Operations", Journal of Petroleum Technology, 12:20-24, Oct., 1960
- 134. Roddy, Thomas C., Jr., "Corrosion Inhibited Gasoline", U.S. Patent 2, 548, 122, April 10, 1951.
- 135. Rudolph, W. "Natural Fungicidal Properties of Fats and Oils", (In German), Naturwissenschaften 32:302. Oct.. 1944.

- 136. Ruggles, Albert C., "Deterioration Inhibitors for a Hydrocarbon Motor Fuel", U.S. Patent 2, 443, 569, June 15, 1948.
- 137. Savolainen, Tapio, "Studies on the Growth-Inhibition of Certain Anaerobic Bacterial Strains by Organic Compounds", Ann. Med. Exptl. Biol. Fenniae 26(suppl. 2):1-177, 1948.
- 138. Seo, M. and Takeshima, S, "Corrosion Prevention in Oil Tankers", Corrosion Prevention and Control, 7(7):32-40,44, July, 1960.
- 139. Simmons, E.J. (chairman), "A Proposed Standardized Static Laboratory Screening Test for Materials to be Used as Inhibitors in Sour Oil and Gas Wells", NACE Tech. Committee Report, Publication 60-2, 1960.
- 140. Stanley, M.E., et al, "Corresion Prevention of Petroleum Transportation Facilities", Amer. Chem. Soc., Atlantic City, N.J., Sept. 16, 1956.
- 141. Sudbury, J.D., Shock, D.A. and Mann, F.W., "A Promising Spray-Applied Inhibitor of Internal Corresion of Oil Tank Ships", Corresion, 10:253-258, Aug., 1954.
- 142. Tringham, T.C.E., "Causes and Prevention of Corrosion in Aircraft", Sir Isaac Pitman & Sons, Ltd., London, 129 pp., 1958.
- 143. Ven Fuchs, George Hugo and Wilson, Norman B., "Rust-Preventive Hydrocarbon Compositions", U.S. Patent 2,442,672, June 1, 1948.
- 144. Watkins, F.M., "Rust Inhibited Distillate Fuels", Proc. 3rd World Petroleum Congress, 8:86, 1951.
- 145. Whalley, W.C.R., "Cathodic Protection and Control of Corrosion in the Middle East", Chemistry & Industry (London), pp. 140-147, Feb., 1954.
- 146. Williams, O.B., "A Comparison of the Susceptibility of Various Strains of Sulfate-Reducing Bacteria to the Action of Bactericides", Producers Monthly, 22(10):12-14, Aug., 1958.

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- 147. Aepli, O.T. and :: Carter, W.S.W., "Determination of Water in Liquid Petroleum Fractions", Ind. Eng. Chem., Anal. Ed., Vol. 17, #5, May, 1945.
- 148. Boord, Cecil E., "Relation of Properties to Melecular Structure for Petroleum Hydrocarbons", Prog. in Petrol. Tech., Adv. in Chem. Series, 1951.
- 149. British Petroleum Company Limited, "An Instrument to Measure Undissolved Water in Aviation Turbine Fuels."
- 150. Case, L.C., "Separation of Aromatic Hydrocarbons by Gas Chromatography", J. Chromatog., 6:381, 1961.
- 151. Development and Proof Services, "Evaluation of COT (Cooperative Oil Test) Military Fuel Testing Engine", Aberdeen Proving Ground, Maryland, Report No. DPS-130, 1959-1960.
- 152. Gardner, L. and Topal, G., "A New Method for the Determination of Undissolved Water in Fuels", Materials Research & Standards, 1(2): 112-115, Feb., 1961.
- 153. Halász, I. and Schneider, W., "Quantitative Gas Chromatographic Analysis of Hydrocarbons with Capillary Column and Flame Ionization Detector", Anal. Chem., 33(8):978-982, July, 1961.
- 154. Kearns, G.L., Maranowski, N.C. and Crable, G.F., "Analysis of Petroleum Products in the C₁₂ to C₂₀ Range", Anal. Chem., 31(10):1646-1651, Oct., 1959.
- 155. Klipp, R.W., "Determination of Trace Sulfur in Leaded Gasoline by Modified Lamp-Turbidimetric Method", Anal. Chem., 33(13):1912-1914, Dec., 1961.
- 156. Knight, H.S. and Groennings, Sigurd, "Fluorescent Indicator Absorption Method for Hydrocarbon Type Analysis", Anal. Chem., 28(12)1949-1954, Dec., 1956.
- 157. Kusakov, M.M., et al, "A Calcium Hydride Method for the Determination of the Content of Water in Fuels under Consideration of the Kinetics of Hydrogen Evolution", (In Russian), Khimiya i Tekhnologiya Topliv i Masel, 3:55-61, April, 1958.
- 158. Lockheed Aircraft Corp., "Detecting Water in Jet Fuel", Lockheed Field Service Digest, 6(1):8-10, July-Aug., 1959.

- 159. Martin, R.L. and Winters, J.C., "Composition of Crude Oil Through 7 Carbons as Determined by Gas Chromatography", Anal. Chem., 31(12): 1954-1960, Dec., 1959.
- 160. Mungall, T.G. and Mitchen, J.H., "A Spectrophotometric Method for the Determination of Moisture and Active Hydrogen", Anal. Chem., 33(10): 1330-1331, Sept., 1961.
- 161. Nelson, K.H., et al, "Gas Chromatographic Determination of C₆, C₇ and C₈ Olefins According to their Carbon Structures", Anal. Chem., 32(9): 1110-1114, Aug., 1961.
- 162. Norris, T.A., Shively, J.H. and Constantin, C.S., "Fluorescent Indicator Adsorption Analysis of Gasoline on Partially Deactivated Silica Gel Columns", Anal. Chem. 33(11):1556-1558, Oct., 1961.
- 163. Nunez, L.J., Armstrong, W.H. and Cogswell, H.W., "Analysis of Hydrocarbon Elends by Gas-Liquid Partition Chromatography", Anal. Chem., 29(8):1164-1165, Aug., 1957.
- 164. O'Connor, J.G. and Norris, S.M., "Molecular Sieve Application to Hydrocarbon Analysis", Anal. Chem., 32(5):701-706, May, 1960.
- 165. Otterson, D.A., "Spectrophotometric Determination of Microgram Quantities of Vaporizable Water from Solids Using Karl Fischer Reagent", Anal. Chem., 33(3):450-453, March, 1961.
- 166. Parker, W.W., Smith, G.Z. and Hudson, R.L., "Determination of Mixed Lead Alkyls in Gasoline by Combined Gas Chromatographic and Spectrophotometric Techniques", Anal. Chem., 33(9):1170-1171, Aug., 1961.
- 167. Roller, D. and Scott, W.R., "Detecting and Measuring Corrosion using Electrical Resistance Techniques", Corrosion Technol., 8:71-76, March, 1961.
- 168. Sanin, P.I., Cherniavskaia, L.F. and Foit, I.F., "Method of Determining Lubricant Corrosiveness", (In Russian), Zavodskaya Lab., 23:696-697, June. 1957.
- 169. Smith, H.M., Kraemer, A.S. and Thorne, H.M., "Aviation Gasoline and its Component Hydrocarbons", Bureau of Mines Bull. 497, 1951.
- 170. Wolochow, H., "The Membrane Filter Technique for Estimating Numbers of Viable Bacteria: Some Observed Limitations with Certain Species", Applied Microbiol., 6:201-206, May, 1958.
- 171. Zakaib, D.D., "Direct Determination of C3 to C5 Hydrocarbons in Olefinic and Non-Olefinic Gasolines by Gas-Liquid Chromatography", Anal. Chem., 32(9):1107-1110, Aug., 1960.

172. Zlatkis, Albert and Lovelock, J.E., "Gas Chromatography of Hydrocarbons Using Capillary Columns and Ionization Detectors", Anal. Chem., 31(4): 620-621, April, 1959.